Saskatchewan
Agriculture, Food
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AGRICULTURE DEVELOPMENT FUND

FINAL REPORT

20020088

ECONOMIC ANALYSIS OF THE
SASKATCHEWAN FEED GRAIN INDUSTRY
AND END USE COMPETITIVENESS

Funded by: The Agriculture Development Fund

November, 2004
Prepared by: University of Saskatchewan

105-02189/

ECONOMIC ANALYSIS OF THE SASKATCHEWAN FEED GRAIN INDUSTRY AND END USE COMPETITIVENESS

FINAL REPORT # 20020088

DEPARTMENT OF AGRICULTURAL ECONOMICS

UNIVERSITY OF SASKATCHEWAN

SASKATOON

AUGUST, 2004

Abstract

Ethanol is a form of alcohol. Ethanol is produced from starch with the primary starch source being grain. The use of price subsidies by governments to support industries like the ethanol industry is neither a new idea nor a particularly good one. The Canadian and Saskatchewan government have embraced the idea that ethanol production can be a benefit to both grain farmers and the environment. This view has been supported by provincial governments in some provinces, such as Ontario and Manitoba howbeit for very different reasons, and by Canadian farm organizations. There is also the view that ethanol is good for the environment, although this view is not widely held. The focus of this report is to measure the economic impact of the Canadian and Saskatchewan ethanol program on Saskatchewan wheat producers. Each of the three prairie provinces have a different ethanol policy, thus we focus on Saskatchewan because it is the largest wheat producer of the three and thus should have the most to gain.

Summary

The Saskatchewan agricultural sector is made up of a number of crop and livestock products, including feed grain production. Feed grains usually refer to feed barley and feed wheat. These commodities are primarily used in the domestic livestock industry and secondarily for export. Both are an important source of revenue for prairie farmers.

The price of feed grains on the prairies is largely determined off the much larger U.S. feed grains complex, dominated by corn. Whatever direction the price of U.S. corn moves the price of feed barley and to a lesser extent the price of feed wheat follows. Therefore the impact of the U.S. Farm Bill, which subsidies corn price, is felt by Canadian feed grain producers. The first half of this research project estimated the impact of the U.S. 2002 Farm Bill on prairie grain producers.

The Saskatchewan government has a policy of trying to develop an ethanol industry in the province. One of the reasons for developing the ethanol industry is to provide a market for Saskatchewan feed grain. By developing a domestic market for feed grain the government has argued that producers would be made better off because they would not need to ship the grain to export. This result depends upon if Saskatchewan becomes a feed deficit area, an unlikely result.

The second part of the research examines the role of feed grains in the Saskatchewan ethanol industry. Given the mandated use of ethanol and the subsidy to ethanol producers the government hopes to develop the industry in Saskatchewan. However, the lower price on feed grains, brought about in part by the U.S. subsidy on corn means Saskatchewan will have a difficult time developing a robust ethanol sector.

Impact of the 2002 U.S. Farm Bill on the Prairie Feed Grain Industry

1. Introduction

Economic literature shows that, to some extent, agricultural policy regimes in Canada are similar to those of its southern neighbour. This relationship has been strongest in the late 20th century. The volume of exported goods and services that flow from the U.S. to Canada has been growing much faster than U.S. exports to any other country, even Japan. This has made Canada the second largest international market for U.S. agricultural products. The establishment of international organizations, such as the North American Free Trade Agreement (NAFTA) and the World Trade Organization (WTO), and the universal idea of free trade among countries are other reasons why agricultural policies in Canada and U.S. are tied together more than before.

Canada's close relationship with the U.S. has raised several common issues between the two countries, two of which are important. The first issue is the interaction between consumers and producers, entailing the payouts transferred from the former group to the latter, and how those transfers are regulated by various agricultural policy regimes posed by the federal government and state (or provincial) authorities. The second issue, which is an outcome of the first, is market distortions. As Gardner (2002, p.l) stressed, "supply response to subsidies influences the production-consumption balance, commodity prices in the North American market, and, through price transmission, commodity prices as well as trade flows elsewhere in the world."

The U.S. Farm Security and Rural Investment Act of 2002 was legislated on May 13, 2002. The new Farm Bill replaced the former U.S. agricultural policy act, known as the Federal Agricultural Improvement and Reform (FAIR) Act, enacted in 1996. An important feature of the

1996 FAIR Act was to remove target prices, deficiency payments, and acreage set-aside requirements from U.S. agricultural policy regimes that changed the direction of the U.S. agricultural section toward more liberalized markets (Schmitz et al., 2002).

Agricultural policies are not legislated in Canada; instead new programs are introduced each year and vary based on the type of agricultural activity. For example, the dairy, poultry, and egg industries operate under supply management. In the grain and oilseed industry, Canada follows a similar pattern with respect to U.S. policy, but with less emphasis on acreage controls and more focus on collective marketing (Gardner, 2002). Several agricultural policies have been implemented in Canada's grain industry. The Western Grain Stabilization Program (WGSP), the Farm Income Protection Act of 1991 that introduced the Gross Revenue Insurance Program (GRIP) and the Net Income Stabilization Account (NISA), the Western Grain Transportation Act (WGTA), the Agricultural Income Disaster Assistance Program (AIDAP), also known as Canadian Farm Income Protection (CFIP), are some examples of these policies. All of these programs were introduced to response to U.S. agricultural policy regimes. For example, the WGSP was introduced in 1976 to assist farmers in stabilizing their on-farm income. Prior to the 1976 Act, grain producers operated under a series of ad hoc agricultural policies in which targets were two-fold: stabilize price and stabilize cash income. The Temporary Wheat Reserves Act, acreage payments, and a guaranteed minimum price for domestically consumed grains are some examples of those policies (Fulton et al., 1989).The WGSP failed ultimately to maintain its initial objectives and was terminated in 1991.

There are a couple of reasons why the WGSP failed to achieve its objectives. First, the U.S. government lowered the loan rate on wheat by one dollar per bushel. Second, the Export

Enhancement Program (EEP) was proposed by the U.S. government in 1985 (Gray and Smith, 1997; Gardner, 2002; Schmitz et al., 2002).

This is a preliminary report of a comprehensive study, where the major objective is to measure the impact of the 2002 U.S. Farm Bill on the Canadian feed grain (wheat and barley) industry on the prairies. In this study, efforts are made to measure acreage response of feed grain growers to a change in some exogenous variables, in particular, world output prices, by using a system of simultaneous equations constructed within a supply and demand framework. The model is built in the supply and demand context because farmers' behavior to various agricultural policies is always a contentious issue for decision-makers. Such reactions can be classified in three factors: output price, input prices, and other relevant factors that affect the environment in which commodities are being produced. Among these, price policies, especially output prices, are the most important factors that influence farmers' decisions in the process of resource allocation. The degree that price policy affects production will depend on the nature and magnitude of supply elasticities. In this case, farmers' decisions will depend on (a) how open they are to changing their crop pattern, and (b) whether they are able to change. To analyze farmers' response to changes in policies and estimate supply elasticity, a separate model of supply and demand is developed for wheat and barley, and the parameters of the model are estimated. Total demand in both models is broken down into components that comprise various uses. The international market is also incorporated, considering Canada's export demand for wheat and barley.

The rest of the report is organized as follows. Problems that might occur from implementing the 2002 U.S. Farm Bill are explained in section 2. Section 3 presents the

objectives of the study. Section 4 introduces various methodologies used to estimate supply (or acreage) response and highlights the strengths and weakness. Section 5 reviews the study of supply (or acreage) response in Canada. Section 6 proposes the model structure used to analyze acreage response to changes in output prices, while section 7 presents and discusses findings from estimating the parameters of the system of equations. The final section concludes the report.

2. Problem Statement

Livestock feeding in Saskatchewan is a growing part of the economy and represents a tremendous value added activity. Since the abolishment of the Western Grain Transportation Act in 1995, feed grains in Saskatchewan have been disadvantaged by higher transportation costs, leading to decreased relative price and incentives not add value through livestock production and processing. The new U.S. Farm Bill threatens this price advantage by effectively decreasing the market price of feed grains in the United States. The policy accomplishes this by creating two prices: a highly inflated price the producer sees and a market price the consumer sees. Excess supply is created as the producer's artificially high price puts downward pressure on the market price and provides advantages to feed grain users through lower prices.

Strategies need to be developed that protect Saskatchewan feed grain users from drastic changes in prices due to U.S. domestic policies. For instance, should Saskatchewan become short of feed grains (net importer from the U.S.), the livestock-feeding sector will lose its advantage relative to U.S. feeders. Therefore, this study will

provide a strategy to protect Saskatchewan producers and consumers of feed grain from highly variable prices brought about by the U.S. domestic policy. Throughout this research, an analysis of the feed grain industry in Saskatchewan will examine uses of feed grain and the relative price sensitivity of consumption. Understanding this relationship with respect to Saskatchewan will assist in understanding the province's significant export of feed grains to Alberta and Manitoba, as well as quantify the potential value added opportunity created by feed grains in Saskatchewan. The feed grain industry continues to develop, and within this development is a movement away from direct least cost ration to a more output oriented least cost ration, which examines the output traits of feed based on species. This development has the potential to expand the value-added activity generated by feed grains and by-products of processing activities. However, it is not known to what extent.

Throughout this research, an analysis of the feed grain industry in Saskatchewan will be completed examining uses of feed grain and the relative price sensitivity of consumption. Understanding this relationship with respect to Saskatchewan will assist in understanding the significant export of feed grains to Alberta and Manitoba, as well as quantify the potential value added opportunity in Saskatchewan created by the feed grain industry. The examination will identify the relative costs and returns of feed grain consumption through livestock and other processes, namely ethanol. The expansion of ethanol plants, which is supported by the provincial government, may cause a conflict with livestock feed users in years of short supplies.

This research will develop a strategy to help the livestock feeding sector and feed grain processors deal with highly variable prices, while at the same time recognizing the

limitations of policy intervention due to the sensitivity of trade relations with the U.S.

3. Objectives of the Study

The primary objective of this research project is to examine how the feed-cost advantage of Saskatchewan livestock feed-users can be maintained in light of the changing U.S. Farm Bill. Saskatchewan is attempting to expand the livestock feed sector, therefore, there is a need to understand the implications of the new U.S. Farm Bill on this sector of agriculture.

The secondary objective of the proposal is to estimate the impact of competing demands on the price and supply of feed grains on the prairies, and examine the possible tradeoff between feed grain use for livestock and ethanol production. Supply of grain for feed and other competing uses have the potential to impact the profitability of the livestock feed sector in Saskatchewan.

4. Models of Estimating Supply (Acreage) Response

A few supply response models have been constructed (Askari and Cummings, 1976; Henneberry and Tweeten, 1991) that estimate supply price elasticities based on the Nerlove's model. However, no public acceptance or rule of thumb exists to determine which model is appropriate. Colman (1983, p.224) imputed several reasons to justify the lack of general consensus. Some of these reasons are types of available data, the computing facility, and the methodology. Some examples of studies that attempted to estimate the supply response models in the context ofNerlove's methodology follow.

One of the most common methods of estimating supply elasticities is to estimate

the supply response model directly by employing a single equation or a system of supply equations. In this estimation, supply of one product is mapped as a function of several variables, such as own-price, related product-price, and non-price variables that shift supply. A measure of supply (quantity produced, seeded area, or harvested area) is chosen as a dependent variable. Although this method of estimating supply function is easy, and the computation of supply price elasticities is straightforward, it contains several shortcomings. The underestimation of short-and-long run supply elasticities, the ad hoc specification of price expectations, and an emphasis on price as the sole index of measuring relative profitability among competing products are some pitfalls of using the direct method of estimating the supply response function.

Taking the mean of all estimated individual factor demand output price elasticities and weighting them based on the elasticity of output with respect to quantity of each input used in production is another method of estimating a supply response function. One advantage of this method is that practitioners do not need to collect information on the underlying technology variable (Henneberry and Tweeten, 1991). Using the method of weighted average of input demand elasticities is not without cost. This approach requires full knowledge of inputs used in the production process.

Another method of estimating the supply response function is the simulation approach. This method, used mostly when making projections, requires the collection of aggregate data. The simulation approach measures changes in the domestic supply function with respect to changes in the world output prices. This task can be easily done by calculating price transmission elasticities.

Linear programming is another method of estimating a supply response function. A

model can be constructed for each individual farm by determining a farm's objective function, specifying the production system using a set of linear and additive production functions for each possible output, and determining a farm's available input levels. By choosing endogenous (output and input levels) and exogenous (output and input prices) variables, given known production technology, the system of production can be solved for different set of output and input prices. Types of data used and the ability to quantify institutional and psychological constraints are advantages of using linear programming, but this method is not able to determine the relationship between output and input prices smoothly.

The last method in estimating the supply response function and determining supply elasticities is the duality approach. Indirect profit and cost functions are the main objective functions derived from rational producers' behavior of profit maximization and constrained cost minimization, respectively. The most important advantage of using the duality approach is its simplicity in estimating the supply function parameters; thus it allows practitioners to use complex functional forms. Moreover, from an econometric perspective, the estimation of simultaneous equations, constructed in the framework of indirect profit approach, is unbiased because all explanatory variables are exogenous (Lau and Yotopoulos, 1972). Using the duality approach requires experts to narrow down an objective function from a country or region to an individual since employing micro data generates more reliable results than using macro data.

5. Studies of Supply (Acreage) Response in Canada

Not many studies discuss supply (or acreage) response in Canada. In this part of the

report, the few that do exist are referred to and their remarkable points are highlighted.

Coyle and Brink (1990) developed a methodology to estimate farmers' responses to the implementation of the Western Grain Stabilization Program (WGSP), Crop Insurance (CI), and Agricultural Stabilization Act (ASA) from the time they were enacted to 1985. To accommodate all these policies into the model, the authors initially used a dual profit function to consider standard properties for a competitive firm that intends to maximize its profit function. The policy variables were taken into account through extending the duality function, which made the program contributors' decision endogenous. Coyle and Brink (1990) estimated parameters of the model using standard econometrics. The results showed that the implementation of the WGSP led to a decline in cultivated acres of oats, rye, and flax and a rise in the cultivated acres of canola. No change was observed in the area under cultivation of wheat and barley. In the case of CI, canola was the only crop where net farm benefits per acre were statistically significant in the model. The results showed that the short-run effects of implementing the ASA program varied among different livestock sectors. The estimate was 0.3 per cent for hogs and -0.5 per cent for cattle.

Meiike and Weersink (1990) studied the impacts of stabilization programs, implemented by both federal and provincial governments in Canada, on total crop area and on land allocation for each crop. They divided the country into eastern and western regions. Barley, soybeans, oats, corn, and wheat were selected in the east, whereas barley, bread wheat, canola, oats, flax, rye, and durum wheat were selected in the west. The authors constructed a linear system of acreage response equations for each of the regions and estimated the parameters of the simultaneous equations using Zellner's seemingly

unrelated regression (SUR), considering cross equation parameter restrictions. Moreover, a simulation technique was used to examine various government support levels to determine the effects of each policy on acreage response.

In particular, Meilke and Weersink (1990) assumed a change in government payments would affect two factors: 1) expected returns from grain crops, and 2) the level of risk considered in the model. Therefore, for each of these scenarios, a simulation technique was carried out to measure the effects of government policies on acreage response. For the first scenario, the researchers excluded the government payments from the calculations of the risk measure. Therefore, this simulation measured only the effects of government payments on acreage response by reducing market uncertainty. For the second scenario, no government payments were considered, which means the total effect of government support was measured through its impact on both the expected returns and variance of returns.

Meilke and Weersink (1990) concluded that if the government payments were removed from the risk measure, total cultivated acres in eastern Canada would decrease by 0.5 per cent, which was equal to 13 000 hectares. This occurred mostly in corn acreage. Major cash crop acreage in the region also fell by 5 percent for corn and 2.2 per cent for wheat. On the contrary, the land allocating for feed crops increased by 2.9 per cent for barley and 0.3 per cent for oats. In western Canada, the results showed that the removal of the WGSP, which increased the variability of measured returns, did not have much impact on the total crop acreage, with an average reduction of 0.02 per cent from 1976 to 1988. However, the elimination of the WGSP payments from expected returns and the risk measure led to a decline of 1.59 per cent in total crop area. Meilke and

Weersink (1990) stressed that if government stopped implementing the WGSP, it would not have a similar impact on the total cultivated acreage for grains. Total acreage for high-value marketed crops (e.g., wheat) would decrease, while an opposite impact would be observed in the case of total area under cultivation of lower-value feed crops (e.g., oats and barley).

Cameron and Spriggs (1991) specified a partial equilibrium model of supply and demand to examine the international effects of the WGSP through using a dynamic stochastic simulation approach. The authors' objective was to analyze how the implementation of the WGSP could cause instability between domestic and foreign markets. Instability between the two market structures was examined through:!) domestic yield instability to the international grain market, and 2) international demand instability to the domestic market.

Cameron and Spriggs (1991) expressed two reasons why enacting the WGSP might cause market distortions. First, it gives unreal signals to those farmers who are risk averse to transfer scarce resources from agricultural activities with more uncertainty to grain production, which was supported by the WGSP. Second, farmers' expectations of receiving payouts from the policy, given their contributions to the program, would increase grain production. The mean and variability of selected variables were two indices of assessing the international effects in the Cameron-Spriggs model. The results of the Cameron-Spriggs study showed that the economic effects of the mean level conformed to economic expectations. That is, grain production, farmers' revenue, and grain exports were predicted to increase slightly and grain prices tended to decline moderately. Furthermore, the authors found that the mean variability effects of

implementing the WGSP had two simultaneous effects: 1) aggravate slightly the transmission of domestic yield variability to the international market, and 2) substantially decrease the variance of the transmission of international demand to the domestic market.

Miranda et al. (1994) examined farmers' responses to the WGSP considering acreage changes as indications of farmers' reactions to government policies. Specifically, the researchers estimated an aggregate acreage supply model for the prairies from 1976 to 1990. Expected values of mean and variances of revenue are considered as ex ante to farmers' rational behavior toward uncertainty about their on-farm income. Six major grain crops, including wheat, barley, oats, rye, flax, and canola, were incorporated into the model. Miranda et al. (1994) were motivated by several changes in government agricultural policy, in particular the introduction and the abandonment of the WGSP in 1976 and 1990, respectively.

Miranda et al. (1994) constructed their model as a series of four simultaneous behavioral equations and two intertemporal material balance identities. Since the authors could not obtain the information related to the expected values and variances of farmers' revenue, they used a combination of conventional parametric econometrics and numerical quadrature integration methods to estimate the parameters of equations in the system. The researchers concluded that the implementation of Canada's WGSP not only maintained the stability of grain acreage but raised it by more than 4 per cent. In other words, during 1976 to 1990, the WGSP shifted grain acreage in a positive direction, and substantively stabilized on-farm income due to a decline in risk and an increase in expected returns of grain growers.

6. Model Construction

In this study, a structural supply-demand response model for Canadian wheat (except durum) and barley on the prairies is designed separately through a system of simultaneous equations. The main objective of constructing both models is to estimate supply elasticities and other necessary information drawn from estimating the parameters of the models, considering acreage response as one source of variation. To do this, a direct method of estimating the models is applied to sample data collected from various sources during the period from 1950 to 2001. Since model specifications in both cases are different, a brief explanation of the wheat model is presented first followed by a description of the barley model. In the latter model, for brevity, only differences between the models are described.

6.1 The Specification of Wheat Model

The system of equations for model of wheat (except durum) consists of five behavioral equations and two identities in a sequence order,

(1) $\log P_t = \beta_0^p + \beta_1^p \log P_t^{US} + \beta_2^p SR + \beta_3^p d_1 + \beta_4^p d_2 + \varepsilon_t^p$

(2) $\log A_t = \beta_0^a + \beta_1^a \log P_{t-1} + \beta_2^a \log Y_{t-1} + \beta_3^a A_{t-1} + \varepsilon_t^a$

(3) $\log Q_t^{DC} = \beta_0^{dc} + \beta_1^{dc} \log P_t + \beta_2^{dc} \log GDP_t + \beta_3^{dc} \log POPU_t + \varepsilon_t^{dc}$

(4) $\log Q_t^{DF} = \beta_0^{df} + \beta_1^{df} \log P_t + \beta_2^{df} \log P_t^{barley} + \beta_3^{df} \log N_t + \varepsilon_t^{df}$

(5) $\log Q_t^{EX} = \beta_0^{ex} + \beta_1^{ex} \log P_t + \beta_2^{ex} \log GDP_t^i + \beta_3^{ex} \log POPU_t^i + \varepsilon_t^{ex}$

(6) $Q_t^S \equiv A_t Y_t + M_{t-1}$

(7) $Q_t^D \equiv Q_t^{DC} + Q_t^{DF} + Q_t^{EX} + M_t$

Equation [1] encompasses the assumption that Canada is a price taker on the world wheat market. In this equation, P_t is the average monthly price of Canadian wheat (#1 western red spring) measured in dollars per metric tonne deflated by the farm product price index (FPPI). Equation [1] assumes that price of wheat in Canada, P_t is a function of U.S. wheat price. The U.S. average monthly price of wheat is deflated by the U.S. producer price index (PPI) and measured through converted exchange rates between the U.S. and Canada. To justify the above assumption, readers are referred to the study conducted by Mohanty and Langley (2003) which showed that Canadian and U.S. grain prices have a long-term relationship and always return to their normal relationships from any deviation. Equation [1] assumes also that wheat price in Canada is a function of global stock ratio expressed as a percentage. Government intervention is taken into account in equation [1] by introducing two dummy variables: stock carry-over indicating one for 1988 and onward and zero otherwise, and the export enhancement program (EEP) expressed as one for the period between 1986 to 1996 and zero otherwise.

In Equation [2], A_t is the seeded wheat area for the Canadian prairies measured in thousands of acres. The area under wheat cultivation is specified as a function of price and yield of wheat, measured in kilogram per acre in the previous year, and its one-lag autoregressive.

Demand for wheat in this system of equations is broken down into three parts: domestic demand for human food, export demand, and domestic demand for animal feed. Equation [3] and [5] show similar variables in the first two equations. Each of the domestic demand and export demand functions is expressed as a function of endogenous

variable, i.e., wheat price, domestic and international gross domestic products (measured in billions of dollars in real 1995 Canadian dollars), and population measured in millions of people in both domestic and foreign countries. In equation [5], Japan and China are considered initially as the two countries that have imported Canadian wheat (except durum) more than any other countries in Asia during 1972 to 2002.

The selection of these two countries is based on a comprehensive review over a series of Canadian export wheat (excluding durum) data, collected annually by Statistics Canada (2003). Table 1 (Appendix) shows Canadian exports of wheat (except durum) by final destination grouped on both geographical and political order from 1990 to 2002. For example, Table 1 (Appendix) shows that near 36 per cent of Canadian wheat exports were shipped to other Asian countries in 2002. The second to fourth places were South (14.2 per cent), North (13.6 per cent), and Central America (13.5 per cent). A detailed analysis of Canadian wheat (except durum) exported to the other Asian countries category, including Japan and China, show that Canada's share in export wheat has always been greater than any other group of countries since 1971. This pattern is seen in each year, including 2000 when the share decreased to 28.99 per cent.

Detailed examination of Canada's wheat exported to Asian countries shows that Japan steadily imported more wheat than China in the 1990s and onward. In fact, Canada's share in exporting wheat to China has declined from 57.9 per cent in 1990 to 7.3 per cent in 2002, whereas Japan's share in importing wheat from Canada has steadily been increasing from 17.6 per cent in 1990 to 39.8 per cent in 2002. Japan was chosen therefore as a representative of an international country in the model.

The last behavioral equation, equation [4], describes domestic demand for wheat as

animal feed. In this equation, the dependent variable is mapped as a function of wheat price, and the price of barley as a major substitute crop. In equation [4], the cattle equivalent index number is based on the table of animal digestible unit (ADU) indicating one cow as a base unit (1.0 ADU) to link the domestic livestock sector to the grain industry.

In the two identity equations, M_t represents stock of wheat held at the end of the crop year. Equation [6] shows that wheat supply in each year is equal to the production of wheat in the same year plus an unused stock held from the previous year. Equation [7] specifies how wheat supply is distributed among various sources of demand in addition to a portion of production that is stored.

6.2 The Specification of Barley Model

As mentioned earlier, barley and wheat models are slightly different. Like the wheat model, the specification of the system of simultaneous equations for barley comprises five behavioral equations and two identities in a sequence order. However different independent variables in the latter model are used. The model is specified as follows:

(8) $\log P_t = \beta_0^p + \beta_1^p \log P_t^{CornUS} + \beta_2^p + SR + \beta_3^p d_1 + \varepsilon_t^p$

(9) $\log A_t = \beta_0^a + \beta_1^a \log P_t + \beta_2^a \log Y_{t-1} + \beta_3^a \log A_{t-1} + \varepsilon_t^a$

(10) $\log Q_t^{DC} = \beta_0^{dc} + \beta_1^{dc} \log P_t + \beta_2^{dc} \log P_t^{malt} + \beta_3^{dc} \log POPU_t + \beta_4^{dc} [\log(POPU_t)]^2 + \beta_5^{dc} \log GDP^{can} + \varepsilon_t^{dc}$

(11) $\log Q_t^{DF} = \beta_0^{df} + \beta_1^{df} \log P_t + \beta_2^{df} \log P_t^{CornUS} + \beta_3^{df} \log N_t + \varepsilon_t^{df}$

(12) $\log Q_t^{EX} = \beta_0^{ex} + \beta_1^{ex} \log P_t + \beta_2^{ex} \log GDP_t^{US} + \beta_3^{ex} \log HOGNO_t^{US} + \varepsilon_t^{ex}$

(13) $Q_t^S \equiv A_t Y_t + M_{t-1}$

(14) $Q_t^D \equiv Q_t^{DC} + Q_t^{DF} + Q_t^{Ex} + M_t$

Equation [8] assumes that price of barley in Canada is a function of U.S. corn price in the market (Kraft and Rude, 2003, p. 14). In this equation, P_t is the average monthly price of barley in Canada measured in dollars per metric tonne and deflated by the FPPI. In this model, the U.S. average monthly price of corn, measured in dollars per metric tonne, is deflated by the U.S. producer price index and converted by appropriate exchange rates between U.S. and Canada. Equation [8] assumes also that the price of barley in Canada is a function of global stock ratio expressed as a percentage. A policy variable showing government intervention is taken into account in equation [8] by adding a dummy variable, which represents feed grain policy indicating one for 1974 and onward and zero otherwise.

In Equation [9], A_t is the seeded barley area in the Canadian prairies measured in thousands of acres and defined as a function of price of barley, the average yield of barley in the previous year Y_t measured in kilogram per acre, and its one-lag autoregressive.

Equations [10] to [12] show that demand for barley is broken down into three parts: domestic demand for malting, domestic demand for animal feed, and export demand. Equation [10] indicates that domestic demand for barley consumption is derived from demand for mailing barley, which is specified as a function of both barley and mailing prices, which are measured in Canadian dollars per metric tonne deflated by the FPPI. Equation [10] assumes also that domestic barley consumption is a function of population, measured in millions of people 18 years and over, and

gross domestic products in Canada, measured in billions real 1995 Canadian dollars. Domestic demand for feed barley in equation [11] is expressed as a function of barley and U.S. corn prices, as a major substitute crop, and the cattle equivalent index number, which is constructed similarly to the wheat model. The international market is also taken into account in the barley model by incorporating Canadian export demand. Equation [12] shows that export demand for barley is mapped as a function of the price of barley and real gross domestic product of the U.S. (as the major importer of Canadian barley), measured in billions of dollars and converted with appropriate exchange rates between the U.S. and Canada. Finally, similar to the wheat model, equation [13] and [14] are identity equations defined as equations [6] and [7].

6.3 Sources of Data

To estimate the parameters of behavioral equations in both wheat and barley models, various sources of data were used. The information related to the domestic agricultural sector, including seeded area, yield, production, farm product price index, total number of livestock, and total exports by final destination, were obtained from Statistics Canada. The data related to the price of malt was collected from annual reports of the Canadian Grain Commission for various years. The information related to total world wheat and barley production was collected from the Food and Agriculture Organization of the United Nations (FAO). The sample data related to the domestic grain prices were obtained from the Canadian Wheat Board (CWB) database. The U.S. data were collected from annual reports of the U.S. Department of Agriculture (USDA). Finally, information at the national level, such as gross domestic products, exchange rate,

and population of Canada, China, Japan, and the U.S., was derived from the International Finance Statistics (IFS) database, an International Monetary Fund (IMF) organization. All data are in logarithmic form, which facilitates the interpretation of the estimated parameters.

7. Estimation Result

To estimate the system of behavioral simultaneous equations in both wheat and barley models, the method of two-stage least squares is used. A few points can summarize why this method is used. First, the wheat and barley price in both models, Pi, is expressed as an endogenous explanatory variable in the system. Since the endogenous variable is a random variable, its value will not be fixed in repeated samples, and changes whenever disturbance terms in the system are altered. This problem violates one of the assumptions of classical linear regression, that independent variables should be non- stochastic and fixed in repeated sampling. Ignoring such a misspecification and running a conventional least squares method will lead to inconsistent and biased parameter estimates. The second reason, which is derived from the first, is that the error terms in all behavioral equations in both models are contemporaneously correlated to each other. Such correlation causes the estimated parameters to be inconsistent and biased, even asymptotically. In this part of the report, the estimation results and discussions for each of the wheat and barley models are presented separately.

7.1 Estimates of the Wheat Model

Table 2 (Appendix) shows the parameter estimates of the five behavioral equations along their asymptotic ^-values in the wheat model. All coefficients' signs conform to economic expectations. In equation [I], the results show that a few of estimated

parameters are statistically significant at a 0.05 level of significance. The coefficient on U.S. wheat price (0.530) reflects the fact that Canadian wheat price follows the U.S. wheat price. This finding corresponds to the study conducted by Mohanty and Langley (2003) indicating a long-term relationship between Canadian and U.S. grain prices. Another coefficient, which is statistically significant in equation [I], is a policy variable constructed as a dummy that controls the export enhancement program (EEP) regulated by the U.S. government from 1986 to 1996. The EEP was proposed as of one of the U.S. stabilization farm policies that subsidized farm products, such as grains. Schmitz et al. (2002, p. 119) stated that "Canadian wheat producers are affected by the export policy of the Canadian government as well as by the policies followed by other major wheat exporting countries, such as U.S. and European Union." The estimated parameter (-0.196) shows that implementing EEP in the U.S. had a negative effect on Canadian wheat production.

The results in Equation [2] show that the estimated autoregressive coefficient related to the seeded area (0.640) is statistically significant at the .01 level of significance, which implies that each year, grain producers adjust (increase) the area under wheat cultivation by 0.64 per cent. The estimated parameters related to the one-lag distribution of wheat yield and price is positive, though they are not statistically significant.

The estimated parameters in equation [3] to [5] show that the domestic demand for wheat and barley is inelastic. Elasticity of demand for wheat and barley is -0.066 and 0.115, respectively. The results also show that the income elasticity for wheat is 0.403, given that the gross domestic product is assumed as the level of consumers' income. The parameter estimates in equation [3] indicate that if Canada's population increased by one per cent, demand for human food will increase by 0.55 per cent. With respect to the

demand for feed, the estimates results show that one per cent increase in animal digestible units will lead to a decrease in demand of feed wheat by 0.31 per cent, indicating that other feed supplements are important for Canadian livestock growers.

Finally, in the international market, the estimated results in equation [5] show that Japanese consumers will decrease their demand for wheat by 0.31 per cent if income is increased by one per cent. This result implies that as the level of income increases, Japanese consumers are more willing to pay for high quality products such as livestock products than for various grains. The result in equation [5] also shows that Canadian exports wheat (except durum) to Japan would increase by 7.5 per cent if the Japanese population growth rate increased by one per cent.

7.2 Estimates of the Barley Model

Table 3 (Appendix) shows the parameter estimates of the behavioral simultaneous equations along their asymptotic p-values in the barley model. All coefficients' signs conform to economic expectations except price of malt, population and population squared in equation [10] (which is kind of a reverse sign), and the U.S. hog numbers in equation [12].

In equation [8], the results show that only the global stock ratio is not statistically significant at the .05 level of significance. Once again, the coefficient on the U.S. barley price (0.856) reflects the fact that price of barley in Canada is following the U.S. corn price (K-raft and Rude, 2003; Mohanty and Langley, 2003). Another statistically significant coefficient in equation [8] is the policy variable that controls the feed grain policy, which has been implemented in Canada since 1974. The estimated parameter

(-0.176) shows that the feed grain policy has a negative effect on Canadian barley production.

The results in Equation [9] show that the estimated autoregressive coefficient of seeded area (0.787) is the only one statistically significant at the .05 level of significance, which implies that each year barley growers adjust (increase) the barley seeded area by 0.79 per cent. The coefficients of barley price and one-lag yield of barley are positive but not statistically significant.

As Table 3 (Appendix) shows, the malt price's coefficient in equation [10] is not significant at the .05 level of significance. All other coefficients of equation [10] are significant with 95 per cent confidence. Domestic demand for feed barley is inelastic, meaning that if barley price is decreased by one per cent, demand for barley would rise by 0.883 per cent. The estimate result also shows that income elasticity for barley is 1.58, indicating demand for barley would have been increased more than one per cent had gross domestic products increased by one per cent.

The parameter estimates in equation [11] indicate that U.S. corn product is a strong substitute for Canadian barley. If the price of feed barley in Canada is increased by one per cent, livestock producers on the prairies will increase their demand for U.S. corn by 0.674 per cent. Equation [11] also shows that demand for feed barley will rise by 1.76 per cent if the cattle equivalent index, computed based on animal digestible units, is increased by one per cent.

Finally, in the international market, the estimated results in equation [12] show that U.S. consumers will increase their demand for barley by 0.51 per cent if U.S. gross domestic products is increased by one per cent. Furthermore, the estimate results in equation [12] show that Canada's export of barley to the U.S. would decline by 0.82 per

cent if the U.S. hog numbers increased by one per cent. This implies that U.S. livestock producers are willing to use more U.S. corn in the rations of livestock.

8. Conclusions

A simultaneous system of behavioral equations is estimated and supply response function and supply elasticity with respect to changing in output price, are computed for Canadian wheat and barley on the prairies from 1950 to 2001. This report is written based on the results derived from the first phase of comprehensive research to measure the impact of the 2002 U.S. Farm Bill on the prairie feed grain industry. Unlike preceding studies, demand for Canadian wheat (excluding durum wheat) and barley is broken down into three parts: domestic consumption, animal feed, and export demand. An international market is incorporated into the model considering Japan and the U.S. as the largest international market for Canada's wheat and barley, respectively. The results show that:

(1) A per cent increase in the price of barley will increase demand for feed wheat by 0.11 per cent, whereas one per cent decline in the price of wheat will lead to a rise of 0.066 per cent in demand for feed wheat.

(2) Each year grain producers would increase their wheat-seeded area by 0.04 per cent if wheat prices in the previous year increased by one per cent.

(3) A per cent increase in the yield of wheat on the prairies in the current year may lead to a rise of wheat acreage in the following year by 0.07 per cent.

4) A per cent increase in the seeded areas of wheat on the prairies in the current year may lead to an increase of wheat acreage in the following year by 0.64 per cent.

(5) Demand for feed barley is inelastic. If the price of barley increases by one per cent,

demand for feed barley will decline by 0.883 per cent, and

(6) A per cent increase in seeded areas of barley on the prairies in the current year will result in a 0.79 per cent increase of barley acreage in the following year.

Application to the Saskatchewan Ethanol Industry

1.0 Introduction

The use of price subsidies by governments to support industries is neither a new idea nor a particularly good one. In the past most price subsidies were applied to the price of the final product, however in some cases input prices have been subsidized. Seldom has the price of the output of one industry been subsidized with stated purpose to positively affect the output price in a second industry. Such is the case in Saskatchewan where one of the rationales for subsidizing ethanol prices is to support the price of wheat. However, this appears to be the approach of the recently announced ethanol subsidy in Saskatchewan.

Ethanol is a form of alcohol. Ethanol is produced from starch with the primary starch source being grain. Such is grain alcohol. The most common form of starch for ethanol is corn and sugar cane. In the United States (US) corn is used to produce ethanol, corn sweeteners and derivatives for animal feed. In Brazil for example, sugar cane is used to produce ethanol, which is burned in automobiles. In Brazil the use of ethanol is mandated for automobiles in the government fleet. Outside of this usage it is more limited in Brazil, even though it can be produced very cheaply from sugar cane.

The US has an elaborate system of subsidies and regulations, which affect the use of ethanol. First, corn prices are highly protected in the US. Corn farmers receive a number of direct and indirect subsidies including deficiency payments, counter-cyclical payments, market transition payments, and subsidized crop insurance. All of these payments, which come into affect under different market conditions, have the effect of increasing corn production. Because the US is a large producer and exporter of corn an increase in production will lower the world price of corn. The lower price of corn is a benefit to the users of corn, one of which is the makers of ethanol.

Some US states require the use of ethanol in gasoline. This regulation is supported for two reasons. First, the claim is made that ethanol is more friendly to the environment than other forms of fossil fuels. Whether this claim is based upon sound science is often debated and is beyond the scope of this study. The second benefit of ethanol is that it uses corn, i.e. removes surplus corn and thus supports corn producers. The growth and development of the US ethanol industry is an on going story. High fructose corn syrup (HFSC) is a big business has HFSC has replaced sugar in soft drinks and many other products. The many agribusiness players in the ethanol industry give it a lot of political clout in the US government and Congress. The subsidies for corn and thus the ethanol industry have become a controversial issue in the US government.

The Canadian and Saskatchewan government have embraced the idea that ethanol production can be a benefit to both grain farmers and the environment. This view has been supported by provincial governments in some provinces, such as Ontario and Manitoba howbeit for very different reasons, and by Canadian farm organizations. Some provinces see ethanol production as one way to reduce their dependency on fossil fuel while others see it as a mechanism to benefit farmers through higher grain prices. There is also the view that ethanol is good for the environment, although this view is not widely held. Already there are some small plants, which produce ethanol such as Pound Maker in Lanigan Saskatchewan. Mohawk Oil uses ethanol in some gasoline products and the ethanol is produced domestically. Alberta encourages ethanol usage but provides no subsidies.

A second reason for farmers to support ethanol subsidies, but one that is seldom stated is that it gets around many of the WTO issues regarding support to farmers.. There is much confusion in the farm community over what is allowed and what is not allowed, but subsidies to protect the environment are clearly viewed more positively than production subsidies. Thus if part of the

ethanol subsidy gets pasted back to grain growers this is not counted by the WTO in the Aggregate Measure of Support. However, there first needs to be some demonstration that farmers receive any economic benefit from ethanol subsidies in Canada.

The focus of this report is to measure the economic impact of the Canadian and Saskatchewan ethanol program on Saskatchewan wheat producers. Each of the three Prairie Provinces have a different ethanol policy, thus we focus on Saskatchewan because it is the largest wheat producer of the three and thus should have the most to gain. This paper builds on an earlier report that examined the impact to the 2002 US Farm Bill on prairie grain production (Furtan, 2003).

To measure the economic impact of ethanol subsidies on Saskatchewan wheat producers we use a standard supply and demand framework. The ethanol market without government subsidies and regulations is quite small. The effect of the subsidy is to shift the ethanol demand to the right, which in turn shifts the demand for feed grain. In the case of Saskatchewan the grain used to feed the ethanol plant will be wheat. The economic effect of the ethanol subsidy can thus be measured in the wheat market.

One of the bi-products of ethanol production is livestock feed. 2004 is not a representative period to measure the impact of the ethanol subsidy on the Saskatchewan livestock market because of the BSE outbreak in 2003 and the subsequent closure of the US border to Canadian live cattle imports. To overcome this situation we will use the period prior to the border closure and measure what the impact of increased ethanol production may mean for the feedlot sector in the province.

2.0 Ethanol Program in Saskatchewan

The ethanol program in Saskatchewan has at least three objectives. The first objective is to support the agricultural sector of the Saskatchewan economy. This is to be achieved through the purchase of grain used for ethanol production and the corresponding increase supply of low cost animal feed for Saskatchewan feedlots. The low cost feed is a direct result of the ethanol by-product. Many people point to the Pound Maker feedlot as an example of such an enterprise. Second, the ethanol program is seen by the government as a method to create jobs in rural Saskatchewan. This is tied to the construction and operation of both the ethanol plant and the feedlot industry. The third objective is to support a clean environment by reducing the pollution that comes from using fossil fuels.

To support the development and on going profitability of the ethanol program the Saskatchewan government has put in place legislation, which provides a 15-cent per liter subsidy to the wholesaler of the gasoline who uses the ethanol. The wholesaler will mix the ethanol and gasoline in a mandated ratio of 2% by May 2005 and 7.5% by November 2005. Thus by November 2005 all of the gasoline used in Saskatchewan, but not diesel fuel, will be an ethanol fossil fuel blend. This subsidy applies only to ethanol produced in Saskatchewan (but need not use Saskatchewan grain as the feed stock for ethanol production). Therefore, the government is using two policy instruments, a mandated quantity and a price subsidy, to support the ethanol industry.

The Government of Canada is likewise supporting the ethanol industry with a 10-cent per liter subsidy. The federal subsidy will also be paid to the wholesaler of gasoline who uses the ethanol. However, the federal government does not restrict the subsidy to ethanol produced in Saskatchewan. If a wholesaler uses imported ethanol they would receive the federal subsidy and not the provincial subsidy.

In this analysis we are not addressing the question of how many or where ethanol plants will/should be constructed in Saskatchewan. This question has been examined in other reports. It is a complex question that depends upon such parameters as the available technology, the cost of the feed stock, proximity to a feedlot and financial security to mention but a few. We do take as a given that there are two ethanol plants currently in progress or on stream. The Lanigan facility currently produces approximately 10-12 million liters of ethanol per year. The Husky plant at Lloydminister is expected to producer as much as 1.3 billion liters of ethanol annually. It is also expected that the Husky plant will dry the ethanol by-product and therefore not be subject to the requirement of have proximity to a feedlot. Other plants have been announced but as the summer of 2004 little action is apparent to bring the plants into production.

A major point of concern is the affect of international trade in the grain and ethanol market when evaluating the provincial ethanol strategy. Trade can occur in both the inputs (grain used to produce ethanol) and in the final product. Corn is the most important feed stock used in the U.S. ethanol industry. Also, corn can be imported into the Canadian prairie region free of any tariffs. Corn is currently used in the feedlot industry both in Manitoba and Alberta, and to a lesser extent in Saskatchewan. Therefore the supply chain for importing corn is well developed. Second, ethanol is traded on the world market with Brazil being the largest exporter. Brazilians use sugar cane as the feed stock for ethanol, which results in a much lower cost product. Currently Canada does not have a tariff on imported ethanol.

Because Canada is a very small producer of ethanol and an open economy the price of US corn and imported ethanol will put effective bounds on the Canadian prices of the respective products (i.e. wheat used in ethanol and ethanol itself). Perhaps this is the reason the Saskatchewan government has chosen two policy instruments rather than one to support the ethanol industry.

3.0 Theoretical Model

To analyze the question of how the ethanol subsidy affects Saskatchewan wheat producers we use a simple economic model, but one that still yields the essential results needed to comment on the programs. Wheat has three uses in this model and they are human consumption and export, feed for livestock, and ethanol production. One tonne of wheat produces 360 liters of ethanol and .33 tonne of animal feed, which can be described in a fixed proportions model, i.e. a Leontif model. Wheat for export, human consumption, and the domestic feed market determine the allocation of wheat for any given price and domestic supply.

The model that will be developed in this paper can be shown graphically as in Figure 1. The graph in the figure 1(a) depicts the ethanol market. The demand for ethanol is D_I and D_B is the demand for the ethanol by-product. The supply of non- wheat inputs into ethanol production is S_N. The derived supply of ethanol is shown as S_I. Given the quantity of ethanol required for the market is equivalent to X_M tonnes of wheat we get the equilibrium prices shown in figure 1(a). The wheat market is shown in figure 1(b). The supply of wheat is S_X. The ethanol demand for wheat is D_E and the total demand for wheat is D_T. The export, human consumption and livestock feed demand is D_T-D_E. With a mandated quantity of ethanol the quantity X_M cuts D_E at price P_X, which is the market price for wheat facing producers.

Suppose the government mandates the quantity X_{mI} of ethanol to be used. In order to get this supply they give subsidy SD. If the price of wheat remains constant (small country assumption) the demand curve D_E will shift to the right to D_E'. The total quantity used for other uses declines. In this case there is no benefit passed on to farmers and all the benefit is picked up by the ethanol industry and a small amount by the suppliers of non-wheat inputs. One group that maybe hurt in this process is the livestock feed industry. They will see a reduction in supply. Rather than push up

the price of feed wheat they will shift to other feed products, such as imported U.S. corn. This is the most likely case facing Saskatchewan, as it does not influence the world wheat price.

The behavioral equations, in price-dependent constant elasticity form, are,

(1) Ethanol demand

$$P_y = ay^{n_y}$$

(2) By-product demand

$$P_z = bz^{n_z}$$

(3) Supply of non-wheat ethanol inputs

$$P_w = cw^{e_w}$$

(4) Demand for non-ethanol uses of wheat

$$P_x = dx_2^{n_x}$$

(5) Supply of wheat

$$P_x = h(x_1 + x_2)^{e_x}$$

where y, z, w, x_1, and x_2 are quantities, P's are prices, n's are inverse demand elasticities, e's are inverse supply elasticities and a to h are constants.

The industrial demand for wheat used in the production of ethanol is not independent of the preceding equations. It is derived in inverse form as:

(6) $$P_x = P_y + P_z - P_w$$

$$= ay^{n_y} + bz^{n_z} - cw^{e_w}$$

As in figure 1, all prices are expressed in terms of tonnes of wheat. Thus, P_y is the dollar value of the ethanol from a tonne of wheat, and P_z is the price of non-wheat processing services per

tonne of wheat. This approach simplifies the quantities also since they are all measured in tonnes of wheat:

(7) $y = z = w = x_1$

After using (7) to eliminate y, z, and w, we are left with the six equations (1) to (6) with six unknowns, P_y, P_z, P_w, x_1 and x_2. There fore, with well-behaved (monotonic, continuous, negatively sloped demand and positively sloped supply) functions, a unique equilibrium exists.

The system can be simplified by substitution using (7) and (6) to obtain:

(8) $P_x = ax_1^{n_1} + bx_1^{n_2} cx_1^{e_w} + s$

(9) $P_x = h\left(x_1 + \left[P_x^{1/n_2}/d\right]\right)^{e_x} - t$

i.e., two equations in two variables, P_x and x_1, and all of the 10 parameters of equations (1) to (5). To carry out comparative statics of policy alternatives, the following steps are taken. First, we add an ethanol subsidy, s, to the derived demand equation (8). The subsidy has the effect of a reduction in the cost of manufacturing ethanol. Second, we subtract deficiency payments per tonne, t, from equation (9). P_x is thus the market price of wheat, while producers get $P_x + t$ per tonne. Instruments s and t have different effects because equation (8) contains only x_1, while (9) contains $x_1 + x_2$.

To analyze the effects of a change in the ethanol subsidy, differentiate (8) and (9) with respect to s:

(10) $\dfrac{dP_x}{ds} = \left(n_1 ax_1^{n_1-1} + n_2 bx_1^{n_2-1} e_w cx_1^{e_w-1}\right)\dfrac{dx_1}{ds} + 1$

(11) $\dfrac{dP_x}{ds} = e_x h\left(x_1 + \left[P_x^{1/n_2}/d\right]\right)^{e_x-1}\left(\dfrac{dx_1}{ds} + P_x^{\frac{1}{n_2}-1}/\left[n_2 d\right]\dfrac{dP_x}{ds}\right)$

There is no straightforward way to solve these nonlinear equations for dP_x/ds, which captures the effect of s on P_x. A numerical solution algorithm could be developed for equations (8) and (9) that,

using any parameter values (n's, e's and constants), finds equilibrium P_x, x_1, and x_2 for any s or t. This was seen as beyond the scope of this study.

An analytical solution is straightforward when equation (1) to (5) are linear (or linearized as a first-order approximation to nonlinear functions). The behavioral equations are then:

(1*) $P_y = a_0 + a_1 y$

(2*) $P_z = b_0 + b_1 z$

(3*) $P_w = c_0 + c_1 w$

(4*) $P_x = d_0 + d_1 x_2$

(5*) $P_x = h_0 + h_1 (x_1 + x_2)$

Equation (8), the inverse derived demand for wheat in ethanol, is now

(8*) $P_x = (a_0 + b_0 - c_0) + (a_1 + b_1 - c_1) x_1 + s$

Equation (9*), obtained by solving (4*) for x_2 in equation (5*), is

(9*) $x_1 = -\frac{h_0}{h_1} + \frac{d_0}{d_1} + \left(\frac{1}{h_1} - \frac{1}{d_1}\right) P_x .$

It is clearer now than in (9) that (9*) is the excess supply of wheat available for use in ethanol. Solving (8*) and (9*) simultananeously for x_1,

(12) $x_1 = \frac{(a_0 + b_0 - c_0 + s)(d_1 - h_1) - h_0 d_1 + d_0 h_1 + d_1 t}{(a_1 + b_1 - c_1)(h_1 - d_1) + d_1 h_1}$

To see the effect of a change in the ethanol subsidy, s, differentiate (12) with respect to s to obtain

(13) $\frac{dx_1}{ds} = \frac{1}{\frac{1}{1/h_1 - 1/d_1} - (a_1 + b_1 - c_1)}$

and

(14) $$\frac{dP_x}{ds} = \frac{dP_x}{dX}\frac{dX}{ds} + \frac{ds}{ds} = \frac{(a_1 + b_1 - c_1)}{\frac{1}{1/h_1 - 1/d_1} - (a_1 + b_1 - c_1)} + 1$$

where $(a_1+b_1-c_1)$ is the slope of the inverse derived demand curve (<0) and $(1/h_1-1/d_1)$ is the slope of the excess supply curve (>0).

[In the case where the derived demand and excess supply functions for wheat for industrial uses is linear in logs, equations (13) and (14) become

(13) $$\frac{Ex}{Es} = \frac{1}{1/\varepsilon_1 - 1/\eta_1}, \frac{EP_x}{Es} = \frac{1}{1 - \varepsilon_1/\eta_1}$$

where E is the percentage change operator, ε_1 is the excess supply elasticity of wheat for industrial uses and η_1 is the derived demand elasticity for wheat in industrial uses. Note that is either $\varepsilon_1 = 0$, or $\eta_1 = \infty$, i.e. wheat for ethanol is fixed in supply or perfectly elastic in demand, P_x rises by the full amount of the subsidy. This means farmers get all the benefit of the subsidy.]

The effect of s on the price of non-wheat inputs (a proxy for profits of the ethanol company) is

(15) $$\frac{dP_w}{ds} = \frac{dx}{ds} \bullet \frac{dP_w}{dx} = \frac{dx}{ds} \bullet \frac{dP_w}{w} = \frac{c_1}{e - n}$$

where $e = (1/h_1 - 1/d_1)^{-1}$ and $n = a_1 + b_1 - c_1$. Also

(16) $$\frac{dP_y}{ds} = \frac{a_1}{e - n}, \frac{dP_z}{ds} = \frac{b_1}{e - n}$$, therefore

(17) $$\frac{d(P_y + P_z + P_w + P_x)}{ds} = \frac{-a_1 - b_1 + c_1 + e}{e - n} = \frac{-n + e}{e - n} = 1$$

Since $-dP_y$ and $-dP_z$ are proportional to the gains to consumers of ethanol and by-products, and P_w and P_x the gains of ethanol producers and wheat producers, equation (17) says that all the gains add up to ds, the change in the subsidy. The interest groups share in the gains as $-a/ds$ for the

ethanol buyers, $-b/ds$ for the by-product buyers, c/ds for ethanol producers, and e/ds for wheat producers. However, wheat producers gain not only on the wheat they produce for ethanol, but also on the wheat used for other purposes, and the domestic buyers of the wheat bare a loss equal to this gain. Therefore wheat producers' gain is $e/ds/\beta$, where β is the share of wheat that goes into ethanol.

4.0 Model and Parameter Values

In order to solve the system of equation (1) through (5) we need the elasticity estimates for the various demand and supply curves. Alternatively, we could use information on the slope of the lines in equation (1*) through (5*). Many of the required parameters have not been econometrically estimated, thus we need to draw from the work of other research.

The elasticity of wheat supply has been estimated at values between 0.5 and 1.0. The elasticity of demand for wheat used for feed and export (plus domestic human consumption) is thought to be in the range of –1.0 to –10. Canada is a small country in terms of world wheat production (approximately 4%) but larger when measured in terms of the volume of wheat traded (approximately 18%). However, as the world wheat market becomes differentiated along quality lines the elasticity of demand may decline somewhat. The demand elasticity for ethanol has never been estimated in Canada. The elasticity used in studies of the U.S. ethanol industry range from –2.0 to –5.0 (Gardner, 2003). The high elasticity is a result of the large number of substitutes for ethanol, which are available in the market. The demand elasticity for ethanol by-products is tied to the livestock feeding industry. The livestock feeding industry in the Prairies is very much in turmoil in 2004 because of the closed US border. If the feeding industry shrinks there will be less demand for any ethanol by-products. In this study we use a demand elasticity of –3.0 to –10 for ethanol by-products. Finally, the supply elasticity of non-wheat inputs to the ethanol industry is 1.0 to 4. The

purchased inputs (excluding wheat) would be perfectly elastic, like labor for example, however the equipment is fixed in the short run, thus the supply curve will have some positive slope.

5.0 Results and Discussion

In this study we conducted three experiments with our ethanol-wheat model. First, we removed the provincial subsidy of 10 cents per liter. Then we removed the total subsidy of 15 cents per liter. In both of these cases the mandated use of ethanol was left in place. Finally, we removed the mandated use and left the subsidies in place.

The second experiment involved changing the supply of wheat. We made the assumption that the supply curve would shift due to a drought so some other such event. We decreased the supply by 5 and 10 percent. The third experiment involved increasing the demand for wheat in the export market. This also involved two cases; one where the price of wheat increased by ten percent when the demand shifted ten percent, and one where the demand shifted but there was no increase in producer price.

The mandated use of ethanol is a constraint to the most efficient use of both wheat and ethanol. There is no demonstrated preference for the ethanol-fossil fuel mix of gasoline by consumers. In addition it will be slightly higher priced than gasoline without ethanol. When the provincial subsidy is removed the price of ethanol falls by 10 cents per liter, but the quantity produced and demanded remains constant because of the mandated use. Thus if 105 million liters of ethanol are required to meet the mandate and a 10 cent subsidy is removed the lost the ethanol industry is $10.5 million. In our model this loss in income comes directly from the wholesaler. The price of wheat is set on the international market and will not be affected by a reduced demand from the ethanol industry. Only is Saskatchewan were on an import competitive basis would the wheat

price be effected by a drop in the ethanol price. When the federal government subsidy of 15 cents per liter is removed a further $15.75 million dollars is lost to the ethanol industry. What our model demonstrates is that the regulation or mandated use of ethanol means any reduction in subsidy is taken directly out of the ethanol industry and has no impact on the wheat price, or quantity of wheat used.

This result raises a number of questions, which are central to the government support of the ethanol industry in Saskatchewan. If the discounted value of the provincial subsidy is calculated at 5% interest the investment is 10.5/.05=$210 million dollars in subsidies alone. If the government is attempting to help wheat producers this is a very inefficient mechanism, because the price of wheat is unlikely to be impacted. The question then becomes how long will this subsidy be maintained by the government? The implication here is that the government probably has other objectives it is trying to achieve through the ethanol program, such as a cleaner environment. Of course if there was no subsidy by the government the industry may not develop, however we do not know what quantity of ethanol the market would supply at different ethanol prices. Second, if the government is attempting to improve the environment, the subsidy and regulation maybe useful. The debate over the usefulness or benefit of ethanol to the environment is not addressed in this study. Third, if the government is attempting to create jobs in rural Saskatchewan through the subsidy it appears to be very ineffective. Almost all of the required ethanol can be produced by one supply – Husky Oil at Lloydminister Saskatchewan.

The second group of experiments deals with the impact on the ethanol industry from changes to the supply of wheat. Prairie farmers know only too well that the supply of wheat can decrease without any corresponding change in price. We model this as a shift of the supply curve for wheat to the left. In our model we use a linear supply curve, thus when we shift it to the left the

elasticity of supply changes (increases). If we increase the elasticity and shift the supply curve by ten percent we raise the equilibrium price of ethanol to $.66 per liter (the mandated usage is still in place). That is the market would have to raise the price of ethanol in order to bid for the required supply of wheat.

This result raises two flags. First, would the gasoline market continue to pay for the use of ethanol with a price increase of $.16 per liter of ethanol? The gasoline price increase would be small (.075 times $.16, or 1 to 2 cents per liter of gasoline). While the mandate is still in place, the there will public pressure to either discontinue the mandate or reduce the amount of ethanol required. In addition, there will be an increase in the pressure to smuggle gasoline from those provinces that do not have such high priced gasoline. Second, the rise in feed wheat prices will reduce the availability and increase the cost of feed grain to the livestock sector in Saskatchewan. If the Saskatchewan government is trying to develop an intensive livestock industry raising the feed grain price will not aid in achieving the objective. Further reductions in the supply of wheat (further shifts to the left) only accentuate the problem.

Some wheat breeding research has been suggested to increase yields of lower quality wheat aimed at the feed and ethanol market. This research could have a substantial payoff if the feed and ethanol industries grow in Saskatchewan. The more important point is how such wheat would fit into the export market and how would it be priced. Farmers are unlikely to plant varieties that are just aimed at the local market unless they are very high yielding or have an alternative market.

Third we conducted some experiments on shifting the export demand curve. This is somewhat similar to the shift in the supply curve. We shifted the demand curve by ten per cent and did not allow for the wheat price to increase thus there is no change in the wheat supply. Second, we shift the export demand by ten per cent and allowed the price to increase by ten dollars per

tonne. In the first case if the exports of wheat increase (priced at $130 per tonne) the local market will be shorted and the price of ethanol will have to increase to bid away the wheat from the export market. Once again other users such as livestock feeders will also have to pay a higher price. If we allow for a price rise when the export demand shifts then the supply will increase and take off some of the competitive pressure.

There are many conjectures we could not test with this model. First, what happens if the ethanol manufactures import corn? Also, what happens if there is a mjor expansion in the livestock feeding industry in Saskatchewan? These are interesting and important questions but do not impact the ethanol industry anymore than a simple shift in the export demand for wheat or a shift in the supply available at current prices. It is not difficult to see that if exports increased and farmers produced a crop with a high percentage of the wheat with high quality, that the ethanol industry would face extreme financial difficulty.

6.0 Conclusion

There are a number of strong conclusions that can be drawn from this report. First, the ethanol industry is built on the availability of low cost feed wheat. If the price of wheat increases or the quantity of wheat available to the ethanol industry is in short supply U.S. corn may have to be imported to maintain the production of ethanol. (Another alternative would be to import ethanol directly from the U.S.) Importing U.S. corn for a feed stock would defeat many of the objectives of the government. Second, without the subsidy the ethanol industry will not develop as a substitute for fossil fuel at this time. Probably the only country where ethanol can be produced at a price competitive to fossil fuel is where sugar cane production takes place (for example Cuba). The industry need for government subsidy makes the ethanol industry very vulnerable to any change in

government priorities. Third, the instability in wheat supply also makes the ethanol industry a risky investment.

The mandated use of ethanol will dampen some of the variability in ethanol production. However, if the price of ethanol rises to bid wheat away from other markets consumers will complain. Consumers will put pressure on the industry in two ways. First, they will lobby the politicians to lower the mandated use of ethanol. Second, they will respond to the increased incentive to smuggle gasoline from lower priced jurisdictions. Both of these actions will weaken the domestic ethanol industry.

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Table 1.Canadian Exports of Wheat by Final Destination (million metric tonnes): 1990-2002.

Year	Total Exports	Western Europe	Eastern Europe	Middle East	Africa	Other Asia	Oceanic	South Amer	Central Amer	North Amer
1990	15.2	0.7	3.0	1.5	0.8	7.3	0	1.0	0.6	0.3
1991	21.3	0.7	6.1	1.4	0.6	9.6	0.004	2.0	0.7	0.2
1992	21.4	0.8	3.8	1.6	0.5	10.4	0.032	2.5	0.9	0.9
1993	16	0.4	1.1	1.2	0.4	7.9	0.023	2.6	1.1	1.3
1994	18.4	0.4	0.1	2.3	0.3	9.6	0.022	2.8	0.9	2.0
1995	13.9	0.4	0	1.7	0.4	8.4	0.032	1.5	0.5	1.0
1996	12.8	0.5	0.05	1.3	0.2	7.0	0.05	2.2	0.6	0.9
1997	17.5	0.7	0.06	3.4	1.4	6.8	0.07	2.6	1.0	1.5
1998	12.1	0.9	0	1.3	1.0	4.4	0.08	1.9	1.3	1.2
1999	11.7	1.1	0.02	2.4	0.6	3.5	0.075	1.4	1.3	1.3
2000	14.9	1.0	0	3.6	0.9	4.3	0.035	2.0	1.6	1.4
2001	14	0.9	0	2.4	1.0	4.4	0.053	1.8	1.8	1.6
2002	8.9	0.8	0	0.5	0.6	3.1	0.024	1.3	1.2	1.2

Source: Statistics Canada.

Table 2. Parameter estimates of the system (wheat model).

Dependent Variable	Independent Variable	Parameter Estimate	Asymptotic p-value
Log P_t	Constant	0.184	0.520
	Log P_t^{US}	o.530	0.009
	SR	0.079	0.146
	d_1	0.026	0.758
	d_2	-0.196	0.030
Log A_t	Constant	0.744	0.598
	Log P_{t-1}	0.035	0.873
	log Y_{t-1}	0.067	0.763
	Log A_{t-1}	0.640	0.000
Log Q_t^{DC}	Constant	0.556	0.831
	Log P_t	-0.066	0.673
	Log GDP_t	0.403	0.483
	Log $POPU_t$	0.550	0.621
Log Q_t^{DF}	Constant	0.661	0.171
	Log P_t	-0.066	0.673
	Log P_t^{barley}	0.115	0.578
	Log N_t	-0.314	0.498
Log Q_t^{EX}	Constant	-31.750	0.048
	Log P_t	-0.066	0.673
	Log GDP_t^{jpn}	0.306	0.229
	Log $POPU_t^{jpn}$	7.504	0.034

Source: Sample data.

Table 3. Parameter estimates of the system (barley model).

Dependent Variable	Independent Variable	Parameter Estimate	Asymptotic p-value
Log P_t	Constant	0.492	0.000
	Log P_t^{corn} US	0.856	0.000
	SR	-0.019	0.394
	d_1	-0.176	0.015
Log A_t	Constant	-0.808	0.465
	Log P_t	0.152	0.549
	Log Y_{t-1}	0.183	0.280
	Log A_{t-1}	0.787	0.000
Log Q_t^{DC}	Constant	19.15	0.001
	Log P_t	-0.883	0.000
	Log P_t^{malt}	0.313	0.114
	Log $POPU_t$	-11.34	0.007
	Log POPU sq.	1.573	0.023
	Log GDP_t	1.581	0.000
Log Q_t^{DF}	Constant	-14.49	0.000
	Log P_t	-0.883	0.000
	Log $P_t^{corn\ US}$	0.674	0.009
	Log N_t	1.759	0.000
Log Q_t^{EX}	Constant	9.391	0.033
	Log P_t	-0.883	0.000
	Log GDP_t^{US}	0.514	0.000
	Log $HOGNO_t^{US}$	-0.882	0.042

Source: Sample data

Table 4.0 Assumptions for ethanol production and consumption.

The assumption is that the ethanol industry will use feed wheat. However, in some years there will not be sufficient supplies of feed wheat, in which case the ethanol industry will purchase 3CWRS.

Saskatchewan will consume .075(1.4 billion liters of ethanol) when the mandate is fully brought into affect. The price of ethanol is approximately US$1.00 per liter. The conversion of wheat to ethanol is 2.5 – 2.7US gallons per US bushel (56lbs). 1US gallon is equal to 3.8 liters. By product is approximately 33%. The price of the by-product is $203 per tonne.

Current ethanol capacity is estimated at: Husky-1.3 billion liters, Lanigan 10 – 12 million liters, and Weyburn 20 – 25 million liters.

One tonne of wheat will produce approximately 360 liters of ethanol. If wheat cost $120 per tonne then the cost per liter of ethanol is $.33.

The conversion of wheat is approximately one-third feed, one-third ethanol and one-third CO_2 on a dry matter basis.

Elasticity estimates

- wheat supply elasticity $\varepsilon_x = 0.5$ to 1.0.
- demand elasticity for non-ethanol uses of wheat $\eta_x = -0.8$ to –10.
- demand elasticity for ethanol $\eta_y = -2.0$ to –5.0.
- demand elasticity for ethanol by-products $\eta_z = -3.$ to –10.
- supply elasticity of non-wheat inputs $\varepsilon_w = 1.$ to 4.

Table 5.0 Estimated demand and supply curves (fully mandated use)

1. Ethanol demand: $P_y = a_0 + a_1 y$, thus $\partial y / \partial p = 1/a_1$ and $\eta_y = \partial y / \partial p \frac{p}{y}$, thus $a_1 = \frac{p}{\eta_y y}$ so for η_y= -2 and p = \$.55 per liter, y = 105,000,000 liters of ethanol when fully mandated.

   Therefore a_1 = (\$.55)/ (-2.)(105 million liters) = -0.0026, and a_0 = (\$.55) – (-0.0026\$/liter)(105liters) = \$.823.

Equation is $P_y = .823 - 0.0026Y$.

2. By-product demand: $P_z = b_0 + b_1 z$, thus $\partial z / \partial p = 1/b_1$ and $\eta_z = \partial z / \partial p \frac{p}{z}$,

$b_1 = \frac{p_z}{\eta_z z}$ so for η_z = -5. and P_z = \$203 per tonne, z = .3(291,666.67 tonne) = 87500 tonne of by-product. Therefore b_1 = (\$203)/(-5.)(87500 tonne) = -0.000464(\$/tonne) and b_0 = (\$203)-(-0.0004644\$/tonne)(87500 tonne) = \$ 243.60.

Equation is $P_z = 243.60 - 0.000464Z$.

3. Supply of non-ethanol wheat inputs: $P_w = c_0 + c_1 w$, thus $\partial w / \partial P_w = \frac{1}{c_1}$ and

$\varepsilon_w = \partial w / \partial P \frac{P}{w}$, $c_1 = \frac{P_z}{\varepsilon_w Z}$ so for ε_z = 2. and P_z = \$134.99 tonnes converted z = 291,666 tonnes.

So c_1 = (\$134.99)/(2)(291666) = 0.000223 and c_0 = \$134.99 –(0.000223)(291666)= \$69.95.

Equation is $P_z = 69.95 + 0.000223z$.

4. Demand for non-ethanol uses of wheat: $P_{x2} = d_0 + d_1 X_2$ thus the elasticity of demand is

$\eta_{x2} = \partial x_2 / \partial p_{x2} \frac{p}{x_2}$ and $\partial x_2 / \partial p = \frac{1}{d_1}$ $d_1 = \frac{p}{\eta_{x2} x_2}$ so p = \$130. tonne, η = -10. and x_2 =

3,708,333 tonne. So d_1 = ($130)/(-10)(3,708,333) = -0.0000035 and d_0 = ($130) –(-0.0000035)(3,708,333) = $143.

Equation is $P_{x2} = 143 - 0.0000035X_2$.

5. Supply of wheat: $P_x = h_0 + h_1 x$ with elasticity of supply $\varepsilon_x = \partial x / \partial P \dfrac{P}{x}$ thus $\varepsilon_x = 1/h_1 \dfrac{P}{x}$

and $h_1 = \dfrac{P}{\varepsilon_x x}$. If P =$130 per tonne, X = 4,000,000 ε_x = 1. we get h_1 =

($130)/(1.)(4,000,000) = 0.000033 and h_0 = ($130) – (0.000033)(4,000,000) = 0.

Equation is $P_x = 0.0000325X$.

So the price of ethanol plus the by-product per tonne of wheat ($198.00 + 66.99) equals the price of wheat and non-wheat inputs per tonne (130.00+ 134.99).

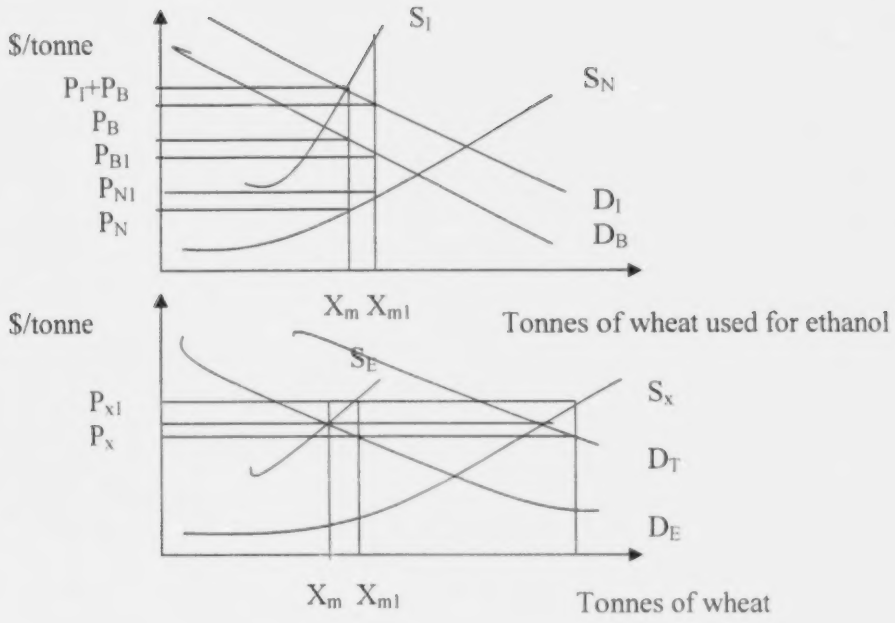

Figure 1.0 Ethanol production from wheat: the fixed proportions case

Conclusions

There are a number of strong conclusions that can be drawn from this report. First, the ethanol industry is built on the availability of low cost feed wheat. If the price of wheat increases or the quantity of wheat available to the ethanol industry is in short supply U.S. corn may have to be imported to maintain the production of ethanol. Another alternative would be to import ethanol directly from the U.S.) Importing U.S. corn for a feed stock would defeat many of the objectives of the government. Second, without the subsidy the ethanol industry will not develop as a substitute for fossil fuel at this time. Only in countries where ethanol can be produced from sugar cane (for example, Cuba) can it be done without a price subsidy and be competitive to fossil fuels. The industry need for government subsidy makes the ethanol industry very vulnerable to any change in government priorities. Third, the instability in wheat supply also makes the ethanol industry a risky investment.

In Saskatchewan the mandated use of ethanol will dampen some of the variability in ethanol production. However, if the price of ethanol rises to bid wheat away from other markets, consumers will complain. Consumers will put pressure on the industry in two ways. First, they will lobby the politicians to lower the mandated use of ethanol. Second, they will respond to the increased incentive to smuggle gasoline from lower priced jurisdictions. Both of these actions will weaken the domestic ethanol industry.